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THE SUBMARINE TOPOGRAPHY OF BASS STRAIT

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Introduction

Of the Australian seas, Bass Strait is one of those which have attracted most attention as regards their submarine relief. Whereas in the Great Barrier Reefs, interest in the bottom topography has been primarily geological and geomorphological, here the stimulus has largely sprung from attempts to understand the modern biological distributions. The means of entry of the Tasmanian aborigines to their island home, the absence of the Australian aborigines and the dingo from Tasmania, the affinities between the freshwater fishes of S. Victoria and N. Tasmania, the former presence of some giant marsupials in Tasmania and not others—these are some of the problems which have led Baldwin Spencer (1892), Howitt (1898), Hedley (1903), Noetling (1910), David (1923), Keble (1946) and Birdsell (1949) to consider the physiographical history of the Strait. It is not the purpose of this paper to venture into these biogeographical questions but rather to re-examine in the light of new evidence the topographic basis itself.

Previous discussions of Bass Strait topography have depended almost entirely on late nineteenth century Royal Navy soundings, which, though close-set inshore, were far from adequate in deeper waters. Indeed the relevant British Admiralty charts, Nos. 1695 A and B, had to depend in parts on soundings in passage up to more than 20 sea m. apart. It is true that Dannevig (1915) relied on his own soundings made in the Fisheries Investigation Ship *Endeavour*. Unfortunately, these were never published and it is thought the records were lost with that ship in 1914. However, since the Second World War, the Royal Australian Navy has carried out a considerable amount of modern sounding in the Bass Strait area. Some of this has been incorporated in recently published charts, Australian Charts Nos. Aus. 145, Aus. 150, Aus. 151, Aus. 199 and Aus. 144. Despite this work substantial areas of the Strait are still sounded in insufficient detail for geomorphological purposes. Nevertheless, since certain of the resurveyed parts are particularly significant morphologically and since the programme of the R.A.N. for some years to come does not include further work in Bass Strait, there seems good reason at the present time to publish and discuss a new map of the submarine topography even though it must still be very variable in reliability.

The Construction of the Map

The sources from which the map was constructed consist of the 'fair sheets' of all the new R.A.N. surveys and bromide copies of the 'fair sheets' of the older R.N. surveys. 'Fair sheets' prepared by the commander of the surveying vessel concerned carry all soundings made. These are much more numerous than the selection carried on the published charts. Access to these 'fair sheets' at the Hydrographic Office,

Garden Island, Sydney, was generously granted by Captain G. D. Tancred and Commander A. H. Cooper. I thank these officers for the facilities they placed at my disposal. I am grateful to Lt. Commander G. C. Ingleton for valuable criticism of this paper. Mr. L. Stewart's help in the Hydrographic Office also requires my thanks.

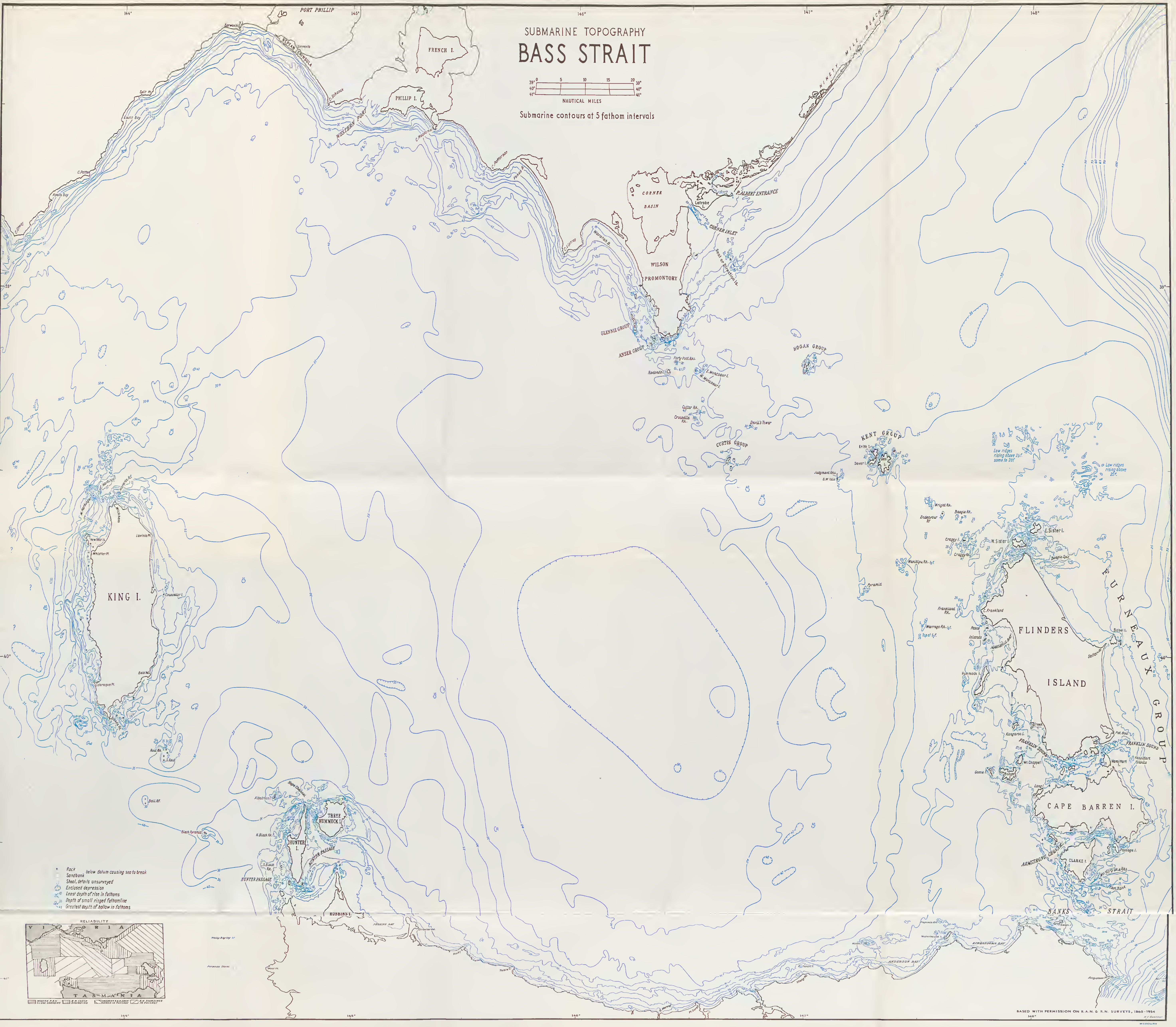
Contours were drawn on tracings to the original scale of the surveys. These were later reduced by pantagraph and assembled using Admiralty charts 1695 A and B as base. Certain gaps were filled solely from the soundings printed on the face of that chart. From this compilation, Fig. 1 was produced by further reduction and generalization. Figs. 2-7 were derived directly from the tracings.

The reliability diagram inset on Fig. 1 indicates that distribution of the different types of survey employed. The W. entrance to Bass Strait, with a narrow extension from Port Phillip to Wilson's Promontory, and the S. part of the Strait from Circular Head to Ringarooma Bay in Tasmania, with an extension northwards to beyond Flinders I. and to the Kent Group, have been charted in rigorous manner. This was carried out between 1946 and 1954 by the surveying ships, H.M.A.S. *Warrego* and H.M.A.S. *Barcoo* under the commands at various times of Captain Tancred, Commanders Hunt, Gale and Cody. The 'fair sheets' are mainly on a scale of 1/75,000 with a few on smaller scales. The parallel lines of sonic sounding were extremely close inshore and were 1-2 sea m. apart in deeper waters, reaching an extreme separation of 3 sea m. apart in a small part of the survey of the W. approaches of Bass Strait. Asdic sweeps were regularly maintained for shoals between the sounding lines.

For the waters around the Hunter Group, King I., Banks Strait, parts of Flinders I., the Kent and Hogan Groups, and the innermost waters along the Victorian coast, recourse was made to copies of the 'fair sheets' of the older Admiralty surveys. The full details are given by Ingleton (1944). Here it suffices to say that the surveys were executed in the periods 1865-1877 (Colonial Steamers *Victoria* and *Pharos*), 1886-7 (H.M.S. *Myrmidon*), 1903 (H.M.S. *Dart*), 1906 (H.M.S. *Penguin*) and 1912 (H.M.S. *Fantome*). Of the various commanders, the names of Staff-Commander H. J. Stanley and Commander R. H. Hoskyns are outstanding in relation to this area. These 'fair sheets' are mainly plotted on a scale of 1/72865, the soundings are generally very close and the derived contours are reliable.

The data are much sparser for the remaining areas. For certain parts indicated in the reliability diagram, continuous sonic soundings in passage by Australian Navy surveying ships were used, the 'fair sheets' were on scales of 1/166,666 and 1/300,000 and the sounding lines were up to 10 sea m. apart. Least satisfactory of all was the basis for the remainder, in particular the SW. part of Bass Strait, where there are still only old Royal Navy wire soundings in passage. These range up to 20 sea m. apart. It can be expected that the run of the contours will be changed by future surveys in all the areas dependent on soundings in passage.

Two points need mention with regard to the drawing of the contours. Where the sounding lines show the same number of fathoms over some distance, the practice of the Hydrographic Office is to draw the fathom line along the deeper side since in the interests of navigational safety it is better to err in the direction of indicating shallower water than may be the case (Fig. 2). In fact, the chances are that the depths where the uniform fathom is recorded are likely to be between this number of fathoms and the next larger number. For present purpose, therefore, the fathom line is drawn along the shallower side as being more likely to represent the actual relief. In consequence the 5, 10 and 20 f. lines on the maps in this article lie in places inshore of those drawn on the related R.N. and R.A.N. charts.



SUBMARINE TOPOGRAPHY
BASS STRAIT
NAUTICAL MILES
Submarine contours at 5 fathom intervals
PORT PHILLIP
FRENCH I.
PHILLIP I.
WESTERN PORT
CORNER BASIN
P. ALBERT ENTRANCE
CORNER INLET
WILSON PROMONTORY
GLENNIE GROUP
ANSER GROUP
HOGAN GROUP
CURTIS GROUP
KENT GROUP
NINETY MILE BEACH
KING I.
FLINDERS ISLAND
FURNEAUX GROUP
CAPE BARREN I.
FRANKLIN SOUND
ARMSTRONG CHANNEL
CLARKE I.
BANKS STRAIT
THREE HUMMOCK I.
HUNTER I.
HUNTER PASSAGE
ROBBINS I.
ANDERSON BAY
RINGAROOMA BAY
Low ridges rising above 25f. some to 20f.
Low ridges rising above 20f.
Rock below datum causing sea to break
Sandbank
Shoal, details unsurveyed
Enclosed depression
Least depth of rise in fathoms
Depth of small ringed fathomline
Greatest depth of hollow in fathoms
RELIABILITY
VICTORIA
TASMANIA
BASED WITH PERMISSION ON R.A.N. & R.N. SURVEYS, 1865-1954

Certain parts of Bass Strait are so gentle in relief that a difference of one fathom can displace a submarine contour markedly. On the 'fair sheets' of these areas, neighbouring sounding lines show in some parts a systematic difference of one fathom (Fig. 3). The result is to impart a regular waviness to the fathom line in sympathy with the direction of the sounding lines. Where this latter direction changes, the waviness changes also. This is clearly fictitious and is possibly due either to tidal rise and fall between neighbouring sounding runs or to some instrumental adjustment. Where this occurs, instead of drawing the fathom line in literal concordance with the soundings, its course is smoothed to represent the condition of the bottom more faithfully. It is clear from such occurrences that to draw fathom lines at intervals as close as one fathom in areas of subdued relief is not usually justifiable. Doubt is felt, therefore, about the basis of certain published figures, e.g. Fig. 7 of Keble (1946). Despite the advances in mapping submarine relief through the introduction of sonic and supersonic sounding, through improvements in position-fixing by radar and other means, the fact remains that submarine contours have still to be interpolated between a series of fixed points without the intervening surface being visible to the eye. Preconceptions as to what one expects to find, can enter too readily into the process of map construction in these circumstances.

The Geological Background

Though the purpose of this paper is to consider the morphology of Bass Strait, the submarine relief cannot be considered apart from the implications, which the rocks of the surrounding land surfaces have for the evolution of the Strait, all the more because geological evidence from the sea floor itself is almost entirely lacking here. I am indebted to Professor E. S. Hills for discussing with me this geological background. The first suggestion of a structural depression, if not an actual sea, corresponding in trend with Bass Strait has been seen in the E.-W. disposition of the freshwater Jurassic sediments of S. Victoria along the margin of the Strait (David ed. Browne 1950, Hills 1955). But the sediments are considered to be derived from the erosion of mountainous country in the location of the present Strait (Edwards and Baker 1943). The tilt of the Jurassic fault block of the Otways towards the Strait points to the origin of the sea (Nye and Blake 1938) but the age of this tilt is obscure. The only Cretaceous rocks known in the area are terrestrial and suggest it was still a land surface then.

Marine Tertiaries, however, are well developed in Victoria from the W. border to Gippsland. They are known also in less substantial development from NW. Tasmania (Gill and Banks 1956) and from some of the Bass Strait islands. Bass Strait certainly came into existence in this time. But how early it appeared and how often its existence was interrupted by regression is not known at all surely since the correlation of Australian Tertiaries is still much debated.

Paleocene-Eocene marine beds reach close to Cape Otway on the W. (Baker 1950). The marine Janjukian formation is known from central Victoria, from E. Gippsland and from NW. Tasmania. The Strait may well have been in existence at this time. Previously this formation was ascribed to the Upper Oligocene-Lower Miocene but, if a recent view (Crespin and Raggatt 1952) is sustained, it is taken back to the Upper Eocene.

In Middle Miocene times, transgression was marked and marine sediments of this date are known additionally from King I. (Crespin 1944), from Flinders I. and Cape Barren I. (Johnston 1877). Perhaps this is the earliest time to which the Strait can be attributed with some certainty.

Pliocene deposits are much more restricted in occurrence, no marine facies being known as yet from the island of Tasmania. But Kalimnan (Lower Pliocene) marine beds occur in Gippsland, the surrounds of Port Phillip and the far W. of Victoria. Marine Werrikooian (Upper Pliocene) occurs on Flinders I. Gill (1957) has recently proposed that the Werrikooian be included in the Pleistocene. This may well be in better accord with the decision of the International Geological Congress that for the Plio-Pleistocene boundary, equivalents of the base of the Calabrian of Italy should be sought.

The Victorian succession reveals marked regressions of the sea in the Tertiary, e.g. in the late Miocene-early Pliocene and a complex story of warping and faulting in several phases. In Tasmania also there was more than one period of faulting in the Tertiary (Fairbridge 1948). Whether landlinks were restored between Tasmania and the mainland in the upper Tertiary, there is as yet no clear evidence.

It is generally assumed that the link was recreated at least once during the Pleistocene, though this is based less on direct stratigraphical data from the region than on the general arguments for glacio-eustatic oscillation and on evidence from other parts of the world for negative eustatic movements of sea level of sufficient magnitude for it to have happened. The occurrence in the Sorrento bore (on the Nepean Peninsula which separates Port Phillip from Bass Strait) of Pleistocene dune limestone (aeolianite) to depths below —400 ft. is not conclusive since this could be due to the foundering of the Port Phillip fault block. Several Victorian geologists have claimed that faulting has continued to recur through the Pleistocene (e.g. Hills 1940). In this regard Boutakoff (1952) points to the dislocation of Pleistocene dune limestone ridges in SW. Victoria. Gill, however, interprets eustatically the occurrence of aeolianite at —67 ft. at Warrnambool in W. Victoria and of buried channels of the R. Yarra at Port Melbourne to depths of —170 ft. The rias of N. Tasmania, e.g. the Tamar, have also been cited as evidence of Pleistocene low sea level stands.

There is more evidence in the region for Pleistocene high sea levels and, as might be expected, the record seems clearer from the tectonically more stable Tasmanian and Bassian island shores. Johnston (1878) reported emerged marine shell beds at 30-50 ft. in the Furneaux Islands. Edwards (1941) found emerged shoreline features at 40-50 ft. well developed in NW. Tasmania. In King I. evidence for a transgression of this order is widespread, though here there is record of a descending sequence of associated transitory shorelines down to present sea level (Jennings unpublished). In NW. Tasmania, Edwards thought that some river terraces were graded to a former baselevel of 100 ft. Beach cobble deposits exposed in the scheelite mine at Grassy, King I., range up to this height also (Nye 1934). Gill and Banks (1956) show that some of the emerged marine features in NW. Tasmania relate to a stand at about 70 ft. From the Victorian side, emerged beaches related to a warm 25 ft. sea level have chiefly been given notice (Gill 1953, 1956). So far there is little by which these various occurrences can be dated within the Pleistocene, though C14 dating shows that the 25 ft. level in Victoria belongs to the last interglacial. For the present purpose, however, they do make clear one thing—namely, that Bass Strait had in the Pleistocene high sea levels much the same extent and form as it has to-day.

Gill (1956) has published the carbon-14 dating of a *Eucalyptus* tree *in situ* at 63 ft. below LWM. in the last buried channel of the R. Yarra at Melbourne. This is given as 8780 ± 200 years ago and belongs to a late phase of the Last Glacial. This find relates in Gill's view to a sea level lower than —100 ft., though this interpretation disregards the possibility of tectonic movement of the Port Phillip fault block since

that date. If it does represent a eustatic shift, the final submergence of Bass Strait must postdate this time. The correspondence with the well-established Flandrian (Boreal) submergence of NW. Europe (Godwin 1945) seems good. Since this submergence there is fairly widespread evidence for a Recent emergence of the order of 10 ft. Such a small shift has little significance for the present purpose so there is no need to argue here the question as to whether it is of eustatic nature, as claimed by Gill and others, or not (Hills 1955).

The Submarine Topography

Particular features of the Strait have been attributed by one authority or another to tectonic movements, to current action, to the operation of waves and of rivers when the relative level of land and sea was different from the present one. From the start it must be recognized that, even in the more closely sounded areas, it will not be possible by any means to be certain always of the nature and origin of these features for, as yet, there is little or no ancillary information to support the morphological evidence. There is no analysis of bottom sediments, no submarine bores, and no geophysical exploration, such as has begun to be carried out in recent decades for other seas, is available. Moreover, as has already been indicated, the soundings themselves are still very inadequate for substantial areas of the Strait. Some of the previous discussions have built too confidently on even more limited data.

Tectonic Features

The major features of the Strait might be expected to be the ones least likely to be modified in their mapping by the refinements of the new soundings and this proves to be so. Moreover, there seems little reason to doubt the general assumption that these major features are tectonic in nature. The major units of the shelf, all recognized previously though some of the names given here deliberately depart from those suggested earlier, are oriented along NW.-SE. and NE.-SW. lines of structural origin (Fig. 4). This is despite the fact that in an overall view the Strait can be regarded as an E.-W. feature.

1. The Bassian Rise ('Bassian Isthmus', Hedley 1903; 'Bassian Ridge', Keble 1946) has attracted much attention in the past since here is the line of shallowest waters between Tasmania and the mainland, and therefore the most likely land-link in the Pleistocene period of oscillating sea levels. In relief it is a low, gently sloping rise, curving slightly from the Victorian coast E. of Wilson's Promontory to the NE. corner of Tasmania and diversified by steeply rising granite masses of various small islands and of the hills of the larger islands such as Flinders I. The abruptness of these hills is indicated less by the heights of Mt. Latrobe (2,450 ft.) in Wilson's Promontory and the Strzelecki Peaks (2,550 ft.) in Flinders I. than by the altitudes to which very small islands such as Rodondo I. (1,150 ft.) and Curtis I. (1,100 ft.) reach.

Though the broad plan of the Bassian Rise is arcuate, the protuberances upon it seem to have a much more linear pattern. Thus the small island groups of the N. exhibit a marked NW.-SE. trend seen for instance in the Glennie Group-Anser Group-Rodondo I.-Cutter Rock-Crocodile Rock-Curtis Group chain and in the Seal I.-Hogan Group-Kent Group-Wright Rock-Endeavour Reef-Beagle Rock-Craggy I. chain. In the Furneaux Group, the trends of the granitic hill masses and smaller islands are much more NNW.-SSE. in direction. The result is that the Bassian Rise adjoins rather than runs into NE. Tasmania.

FIG. 4.—Some tectonic features of S. Victoria and N. Tasmania in relation to Bass Strait submarine topography. Fold axes mainly Palaeozoic, faults mainly Tertiary. Based on published maps of Boutakoff, Carey, Condon, Fairbridge, Hills and Thomas. Further faulting in the Otways is known to exist but there are no published maps. Only the most clearcut tectonically controlled submarine features are shown.

The Rise, termed the 'Eastern Granite Arc' by Lewis (1936), follows ancient tectonic structures very obviously. Though David and Browne (1950) regard these granites as Carboniferous, as yet, there is no evidence that the relevant Kanimblan orogeny affected Tasmania, and Carey (1953) considers both the granites and the folding of the Mathinna sediments of the Furneaux Group to belong to the Taberabberan (Mid-Devonian) orogeny. He maps an anticlinorium running NNW.-SSE. through the Furneaux Group, parallel to other fold structures of NE. Tasmania. It seems likely that this anticlinorium is continued into Wilson's Promontory though

beyond that the axial trend of Lower Palaeozoics just N. of Waratah Bay is NE.-SW. (Thomas 1934).

No later earth movements have actually been proved from this eastern chain of islands but it is unlikely they escaped them. One noticeably straight lineament in the submarine topography can hardly be interpreted as other than due to young faulting, probably of Tertiary age. This is the straight scarp close inshore from W. Sister I. to Cape Frankland, Flinders I., some 13 m. in length and rising from 20 f. Its direction is SSW. to NNE. and is paralleled by other shorter straight lineaments—(1) NW. of Hummock I., (2) NW. of Craggy I., (3) E. of Deal I., and (4) between Deal I. and Dover I.

The gently bowed foundation of the Bassian Rise has a flat crest along a line through the Hogan and Kent Groups and this reaches up to depths between 30 and 35 f. The isthmus of water shallower than 30 f. shown by Noetling (1910) and by David ed. Browne (1950) is not supported by the available soundings. On the other hand, an emergence of 35 f. would uncover a wide land surface linking Tasmania with the mainland as Howitt (1898) saw, though its width would be 40-50 m., not the 80-90 m. of that author.

2. The King Island Rise ('King Island Ridge', Keble 1946) is neither structurally nor topographically a complete counterpart of the Bassian Rise. It ends just N. of King I., which is separated from Cape Otway by the deepest water belonging properly to Bass Strait. Little can be learnt of its detailed topography since the soundings here are most scattered, except in the immediate vicinity of the Hunter Group and King I.

The Hunter Group, like the Furneaux Group, has fairly prominent granite hills rising to nearly 800 ft. in Three Hummock I. Though there are granite hills in King I., they are less prominent than the plateau of metamorphosed sediments, which rises sharply from the sea in the SE. to a height of 550 ft. and declines gradually northward and westward. The sediments are correlated with the Cambrian Dundas Group and Precambrian Carbine Group (Carey 1953). As with the Bassian Rise, the present topography follows ancient structural trends. Here also the granites (Lewis's 'Western Granite Arc') are regarded as Devonian by Carey and the Heemskirk Anticlinorium of NW. Tasmania is continued by him NNW. into King I. where the metamorphics have nearly this strike. The Hally Bayley shoal, Black Pyramid, Bell Reef and Reid Rock, some of which are of granite, rise sharply from the continental shelf on this line. The Hunter Group lies to one side and it is possible that a second Taberabberan anticlinorium runs through them.

The Hunter Group, however, is cut off abruptly on the N. by a sharp linear submarine feature, much in the same fashion as is Flinders I. though here the direction is nearly E.-W. Once more this is likely to be due to young (Tertiary?) faulting. An even clearer indication of such movement is found in the very pronounced lineament running NNW. for some 20 m. from Stokes Point at the S. end of King I. This is nearly parallel to the strike of the metamorphic basement of the island. More discordant with that structure are certain short but sharp features along NW.-SE. lines on either side of and between the W. and E. Harbinger Reefs. This trend, however, is continued in the low granite ridges of the N. end of the island.

It was Dannevig (1915) who pointed out that the shallowest connection, nowhere as deep as 30 f., runs in the form of a crescentic arc from the NE. of King I. to the main island of Tasmania E. of the Hunter Group. The fact that it does not directly join the Hunter Group and King I. offers some support to Dannevig's view that this

arcuate rise is the result of modern sedimentation. He pointed out that the shelf W. of King I. is very rocky and attributed this to storminess and strong currents. In the passage between King I. and the Hunter Group, conditions, he thought, were still too rough for anything but coarse sand to rest so that the finer materials were thrown into the Strait to accumulate as a curving bar. It may be too broad and substantial a feature to be explained in quite such terms but that sedimentation may have been favoured here over a much longer period of time is an idea more readily accepted to account for it. In fact, soundings are far too widely scattered for a confident notion of even the form of this connecting arc, quite apart from questions of interpretation.

3. THE TAIL BANK, named by Dannevig, is seen on the present map to be so ill-marked in form and extent as scarcely to warrant separate consideration from the King I. Rise, which it adjoins on the SW. But its trend (NW. to SE.) does differ from the latter's and it has been discussed, not only by Dannevig, but also by Noetling and Keble. Some individual notice of it is therefore appropriate.

Noetling (1910) maps a long ridge running southwards from the neighbourhood of Cape Schanck to shallow waters E. of the N. end of King I. Depths of less than 30 f. follow most of its length but depths between 30 and 40 f. are shown close to Cape Schanck. On the basis of his own soundings, Dannevig claimed this was wrong and the modern soundings substantiate him. Its trend is NE. towards Cape Patterson and it scarcely anywhere reaches the shallowness of 30 f. Moreover, the 40 f. lines fail to link the Bank either to Cape Schanck or to Cape Patterson. Admittedly, close parallel lines of sounding are still lacking over much of the Tail Bank but the soundings in passage now available provide a surer basis than the data Noetling used.

May (1923) argued that the last landlink between King I. and Tasmania was broken before that between King I. and Victoria because one species of land snail, *Chloritis Victoriae,* is found in Victoria and King I. but not in Tasmania. Since the former link is now less deeply covered by water than the latter one, this view cannot be explained by eustatic shifts alone but must involve some differential tilting. However, Keble felt no difficulty in regarding the Tail Bank-King I. Rise as a more important migration route to Tasmania than the Bassian Rise, even though in Keble's view the latter shallower connection must have lingered longer than the former. Clearly there is no reason why some species should only have spread as far as King I. when all the landlinks were broken by the Flandrian transgression, known from European evidence to have been a very rapid one.

Dannevig regarded the Tail Bank as another recent constructional feature of similar origin to that of the arcuate rise between King I. and Tasmania. In contrast, Keble thought it represented an extension of the peneplaned foundation of King I. to the NE. At present there is little to go on in this matter though the rather sharp 'nose' of the Tail Bank around 144° 15'E. 39° 20'S. is perhaps indicative of bedrock there at least. In addition, the NE. trend of the Bank, admittedly not very clearcut, is continued in both the relief and the tectonic lines of the S. Gippsland Ranges.

4. THE BASSIAN DEPRESSION, enclosed between the three positive features already described, is a remarkably featureless and very shallow basin, indeed its relief hardly warrants the name of 'Bassian Trough' which Lewis gave it. How deep it reaches is still somewhat uncertain for soundings in passage alone are available for the central part within the 45 f. line. Dannevig mentions a maximum depth of 53 f. but the small ringed 50 f. lines shown on the present map are based on old wire soundings. In general in this area, the modern sonic soundings give shallower

depths than these earlier results. Certainly nothing much deeper than 50 f. is to be expected and that over very limited areas.

Structurally, of course, it is very likely that there is a tectonic trough here since the elongation of the depression is in continuation of the Midlands Graben of Tasmania as Lewis pointed out to be supported later by Fairbridge (1948). It is possible that the Western Tiers faultline, which bounds the Midlands Graben on the W., is represented on the floor of Bass Strait by the line of steeper slope running some 50 m. NNW. from Table Cape. But this is by no means a sharp feature, rising only 10 f. over a distance of nearly 10 m. At most it is a gentle warp. The Blue Tiers faultline, limiting the Midlands Graben on the E., finds no counterpart at all in the Bassian Depression. This lineament produced crosses the very smooth central parts of the depression. The bounding slopes of the basin are in general exceedingly gentle and clearcut limits cannot be discerned. This must be qualified for the S. Victorian coast, where the Glennie Group is cut off on the W. by a very sharp feature, which may well follow a faultline.

These subdued characters argue against the standpoint of Lewis and Fairbridge that the present relief of the Bassian Depression is the result of very young faulting. Their argument that such a large enclosed depression must be tectonic in origin is acceptable, but Fairbridge's further inference of very recent formation from the fact that the basin has not been infilled by sediment and lacks a continuous outfall is less so. It ignores the fact that the history of the basin must have been mainly a submarine, not a subaerial one, and so elimination by sedimentation is less likely. It ignores also the shallowness and lack of sharp bounding features of the basin. As already has been seen, Dannevig disposed of Noetling's idea that there must have been a large deep lake or inland sea here during some at least of the Pleistocene glacial periods. The deepest parts of the depression are perhaps some 10 f. deeper than the deepest outlet channel between the Tail Bank and the Victorian shore. Partial sedimentation of an older fault trough seems to fit the topographic facts better. Nothing in that topography demands that the downfaulting of the Bassian Depression should be later, for example, than the Lower Miocene age proposed by Nye and Blake (1938).

5. The Otway Depression. At the W. entrance to Bass Strait between Cape Otway and King I. the waters are deeper than anywhere else in the area under study. Depths greater than 60 f. are found not far NW. of the N. end of King I. and along a line from Cape Wickham to Cape Otway the bottom is mainly below 50 f. The 40 f. line reaches far north-eastwards to enter the northernmost bight and to link with the Bassian Depression around the Tail Bank. This Otway Depression ('Otway Trough', Lewis 1936; 'Bass Strait Sunkland', Keble 1946) is bounded very clearly on the NW. by the remarkably straight and steep submarine slope from the neighbourhood of Barwon Head to a point beyond Cape Otway in the open sea. Hills (1946) shows in his Fig. 346 the Otway Ranges to be strongly downwarped and faulted along this flank. Keble (1946) produces the Bellarine Fault of Port Phillip to run along the sea floor a little E. of the foot of the submarine cliff. There can be no doubt that here is a major structural feature.

No such well marked feature limits the depression on the SE. though the Tail Bank has been noted previously to have a parallel trend. Keble (1946) carried the Selwyn Fault of Port Phillip's E. shore across to King I. The present map gives less topographic support for this than does his Fig. 12. Nevertheless, the general run of the contours in the Otway Depression is consonant with the notion of this being a

downthrown block, which is more closely the continuation of the Port Phillip Sunkland than the Bassian Depression, to which Lewis assigned this relationship.

6. THE FLINDERS DEPRESSION ('Flinders Trough' of Lewis 1936) lies wholly outside Bass Strait proper but it is included in the continental shelf of which the Strait occupies the predominant part. Soundings here are too inadequate for any concern with details of relief. In the large there can be seen, between the Bassian Rise and the top of the continental slope here at 45-50 f., a depression formed by a south-eastward slope from the Gippsland shore and a north-eastward slope from the Bassian Rise. Where these two slopes meet lies the NE.-SW. axis of the depression and a fault or down-warp, increasing in magnitude north-eastwards along this line, suggests itself as the origin of the feature as a whole.

Pleistocene Low Sea Level Fluvial Features

Some mention must perforce be made of Noetling's confused and highly speculative notions of a late-glacial and early postglacial drainage system on an emerged Bass Strait, disrupted by volcanism and subsidence in the last 7,000 years. In his Fig. 2 the E. Gippsland rivers join to enter Bass Strait on the NE. and leave it between King I .and Tasmania. At the same time, the Yarra flows in a roughly parallel course across the shelf on the other side of King I. The 40 f. line is cited as showing traces of these old river courses but it is difficult to see the basis of this supposition in the present map. Then at a later stage (Noetling's Fig. 8), presumably after the beginning of subsidence, a large deep lake developed across the course of the first of these postulated major rivers and the drainage of Western Port fell into this lake. With these connections a common river fauna was established between S. Victoria and N. Tasmania. Dannevig showed that there was no high ridge between the Otway and Bassian Depressions as Noetling supposed and that a very gentle and small tilt down to the SE. could have destroyed a former continuous outfall from N. Tasmania to the N. bight of Bass Strait. Alternatively, differential marine sedimentation over a comparatively short space of geological time could have created the low barrier which does exist between the two.

Dannevig's standpoint was that if the floor of Bass Strait has been exposed, the drainage system would have taken the form of a Tamar Major river flowing NNW. into the bight S. of Port Phillip Bay, where it would have collected the Yarra as a tributary and swung round to the SW. to flow out between Cape Otway and King I. to the sea.

Since Dannevig wrote, the concept of the glacio-eustatic control of sea level during the Pleistocene has been widely examined and received so much supporting factual evidence, apart from strong *a priori* arguments in its favour, that such control can now be regarded as an accepted principle (see, e.g. Flint 1957). As part of this development has come the recognition of subaerially fashioned topography on the continential shelf as for instance in the relict river channels in the floor of the Sunda Sea (Umbgrove 1929) and glacial moraine lines on the bottom of the North Sea (Pratje 1951).

There was then a different climate of opinion when Keble (1946) discussed the Bass Strait topography. Since the general estimate for the fall of sea level in the Pleistocene glaciations is of the order of 300 ft. (Kuenen 1950, Flint 1957), it was logical on the basis of theory to expect to find evidence of river channels on the Bass Strait floor. In his Fig. 12, Keble drew fresh contours for the Otway Depression, based perforce at this time on the old soundings. These contours show a clear-cut Yarra channel and several tributary channels defined by the 45 and 50 f. lines. He

also adopted Dannevig's Tamar Major river, though he does not show any sign of it on that portion of his map which would have been crossed by such a confluent stream.

Close modern sounding is now available for most of the area covered by Keble's Fig. 12. Differences of interpretation are now closely limited by the data, which do not permit of Keble's construction. The 45 and 50 f. lines do not reach into the NE. half of the Otway Depression at all. In reality it is practically featureless. Captain G. A. D. Tancred, at the time in charge of the Hydrographic Office, expressed the opinion that it is one of the flattest areas of shelf floor to be found. It will be evident that this comment applies to many other parts of Bass Strait as well. Reasons have been given above for the view that the drawing of submarine contours at much closer interval than 5 f. over subdued relief may be misleading. But if such closer contours are drawn in this area, the resultant pattern is more suggestive of NE.-SW. structural lineaments parallel to the Otway's submarine scarp than of any river course.

If attention is turned to the S. reaches of Bass Strait where close sounding again reaches well out from the coast, the general smoothness and featurelessness is outstanding and traces of features resembling river channels cannot be found on the flat floor of the Strait. In any case, where the gradients are as slight as they are here, there must be serious doubt whether any small bend in a single contour is a real thing and not a minor error in survey. Closer inshore, the slopes are steeper and a group of sympathetically arranged bends in a sequence of adjacent contours would certainly reveal a real feature. Even here there is no positive indication of a submarine channel of the Tamar below the 15 f. line, though inside this line there is the well known ria of Port Dalrymple along the Tamar (cf. Edwards 1941). Of all the N. coast rivers, the only one where something indicative of a channel at lower levels can be discerned is offshore of the R. Mersey mouth. The 20, 25, 30 and 35 f. lines all have reentrants so placed with regard to one another that they could be regarded as the result of the Mersey flowing down this slope of about 15 ft. to one mile. Edwards (1941) regarded several depressions in the Hunter Group reaching to 25 f. as submerged river valleys. Reasons are given later for considering them instead as due essentially to current action on the sea floor.

The conclusion to be drawn from this negative search is not that the lower parts of Bass Strait were never exposed subaerially in the Pleistocene. Evidence from all over the world, from the peatbeds of the S. North Sea to the rias of the Derwent or Broken Bay can be regarded as conclusive in this respect. It is more simply that Keble neglected to weigh the work of the sea during still stands at higher levels than those which must have permitted fluvial action on the Bass Strait floor and during the periods of rise and fall between high and low sea levels. Cotton (1951) has recently reminded us of this danger. Nor must it be forgotten in this connection that Bass Strait is widely regarded as one of the stormiest of the partially enclosed seas of the world. Dannevig did not make this mistake of underestimating marine action, both by waves and by currents. He did not claim to recognize actual river courses but only inferred their probable general direction assuming the floor were exposed. On the contrary he was at pains to assess the variation in marine erosion and sedimentation from one part of the Strait to another. The central floor of the Strait is so flat that any low sea level river courses would be very shallow, meandering channels, soon concealed by later marine sedimentation or erosion. Moreover, it is likely to be developed on weak sediments below. In this context it would probably have been more surprising to have found relict river channels than to have failed to do so as it proved.

Pleistocene Low Sea Level Littoral Features

It would be consonant with the arguments just presented to find evidence of marine cliffing at lower levels than that associated with the present stand of sea level. David (1923) has claimed such evidence in these waters. He interpreted the steep submarine slope west of the central part of King I. as a coastal cliff cut when sea level was at — 33 f. This slope is part of the larger linear feature discussed above as an expression of faulting. The N. half certainly does have its basal break of slope between 30 and 35 f. but the S. part of the scarp starts higher.

There is not necessarily a conflict between the two interpretations. A fault scarp may be sharpened and retreat slightly by marine attack, yet retain its original character and linear plan essentially. Low sea level wave action may keep its base clear of enveloping sediment to a particular level or may plane the downthrown block to that same level. Whether such a compound origin applies here calls for a more extended view. Thus 5-6 m. W. of Stokes Point there is a shoal area rising quite steeply to 10 f. from a basal break of 30-35 f. SE. of King I. the shoals around Reid Rock and the Bell Reef both rise to the surface from the 30 f. line.

Across the Otway Depression, the straight submarine scarp from Barwon Head to Cape Otway, which as has been seen can hardly fail to be a tectonic feature, has nevertheless a consistent break of slope at 35 f. Moreover, the same break of slope is found round to Cape Schanck in front of the Nepean Peninsula of different and much younger geological structure. Keble interpreted this 35 f. level as the shoreline at the beginning of his Pleistocene Upper Dune Series. He regarded this shoreline as carried down to this level by tectonic subsidence of the Port Phillip Sunkland, though he did also incorporate large glacioeustatic shifts in his general interpretation of the area.

This marked break of slope at 35 f. continues along the coast to Wilson's Promontory, with varied geological structures backing different parts of the coast. This statement needs qualifying for two sections. At Wilson's Promontory itself the submarine scarp rises at some points from 40 f. where strong tidal currents seem to have fashioned scourcolks. Between Cape Woolamai and Cape Patterson, the slope down to the flat floor of the Strait is in two sections with an intervening step. This step ends coastwards at the 20 f. contour and projects some 20 m. seawards in a blunt point directed at the Tail Bank and defined by the parallel courses of the 30 and 35 f. contours. In plan the whole feature makes some sharp bends between Cape Schanck and Wilson's Promontory in keeping with the coast and overall structural control cannot be doubted. But the prevalence of the 35 f. break of slope practically continuously from Cape Otway to Wilson's Promontory is out of keeping with an interpretation solely in terms of a series of inter-connecting true fault scarps. It would be surprising if the separate downthrown blocks managed to retain the same level over a distance of 180 m. More reasonable is it to suppose that marine erosion and sedimentation has produced this uniformity in level in a topography initially the direct result of faulting. And such marine action would appear to relate to a low sea level of the order of 30-35 f. below the present sea level.

Many of the small islands and reefs between Wilson's Promontory and Flinders I. offer further evidence in support of this interpretation. The subaerial slopes and cliffs of islands such as Rodondo, the Moncoeurs, the Curtis Group, the Hogan Group, South-west Isle and Pyramid I. continue unbroken below sea level to 30-35 f. where they abut abruptly on to the flat floor of the Strait (Fig. 5). Many of these features warrant the name of 'plunging cliffs' (Cotton 1951). It is significant that in a number of cases, e.g. South-west Isle, this characteristic is better developed on

the W. side than on the E. side where the banks on which the island or reefs rest tail off more gradually. W. coasts are on the weather side in Bass Strait and are subject to a much more violent wave attack.

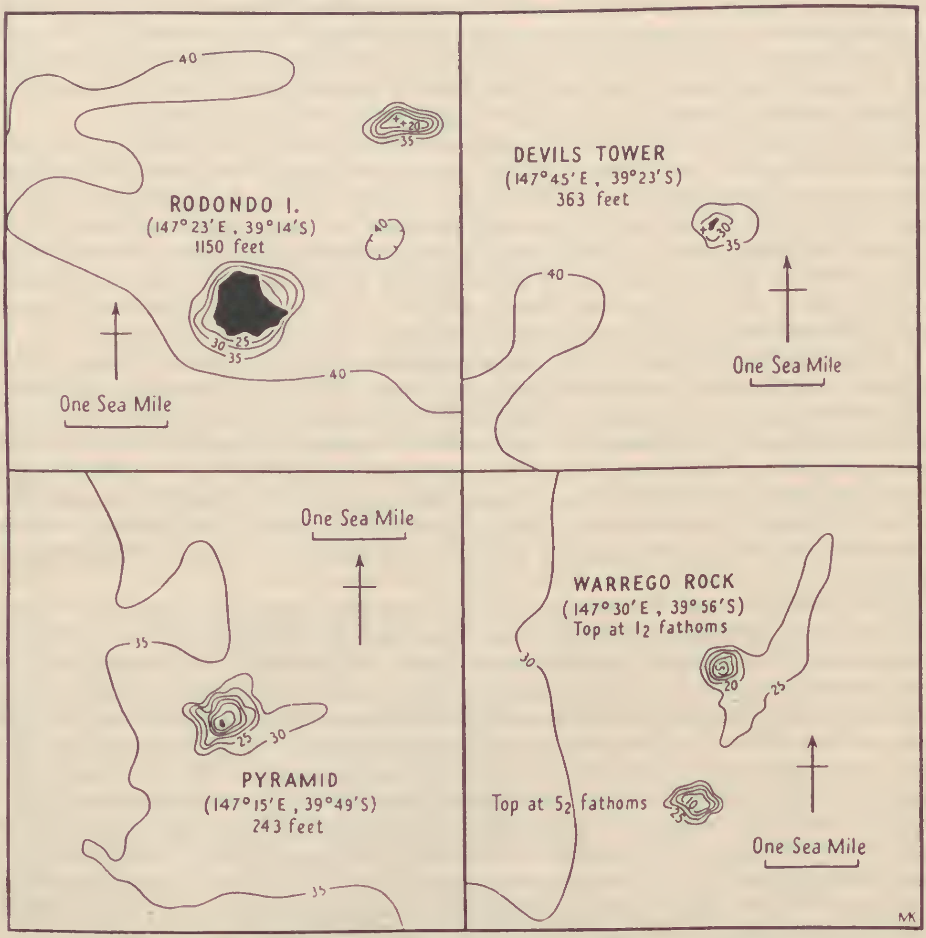


Fig. 5.—Some examples of 'plunging' granite islands of the Bassian Rise.

King I. and Flinders I., together with its smaller neighbours, show a similar contrast between their W. and E. sides. The easterly-facing coasts in both cases lack the sharp submarine features. In the case of SE. King I. this is despite the fact that the coast rises sharply to a 200-500 ft. plateau level and has been interpreted as a fault coast (Debenham 1910). On a wider scale still the W. sides of the Bass Strait Rise and the King I. Rise are more accidented in bottom topography than the much smoother E. sides. Dannevig associates this distributional pattern with the variation in storm waves and tidal currents of present-day conditions. Moreover, the general easterly set of the Southern Ocean current must help to produce this contrast by inhibiting sedimentation on the W. sides of the Bassian islands and allowing it in

their lee. But variation in exposure to marine processes when sea level stood lower at various times in the Pleistocene is probably more important. These steep submarine slopes with sharp basal angles are regarded then as the record of low sea level marine erosion, clearest where this agency operated upon previous fault features.

However, the picture is not as simple as it has been indicated so far. Similar submarine breaks of slope occur at much shallower levels than those already mentioned. The Kent Group and Pyramid I. rise from 30-25 f.; Wright Rock, Endeavour Reef, Craggy I., Wakatipu Rock, Frankland Rock, Warrego Rock, and its neighbouring shoal, all rise from 20-25 f., as does the faulted scarp NW. of Flinders I. All the islands lying W. of Flinders I., from the Pascoe I. to Goose I., have sharp breaks on their W. sides at 20-15 f. This is true also of Waterhouse I. and Ninth I. off the Tasmanian shore. W. and N. of the Hunter Group and around Albatros I. and Black Pyramid the basal break of slope is at 20-25 f.

This variety of level of the submarine breaks of slope is not regarded as vitiating the conclusion already reached. It remains evident—(1) that they are not all structural in origin and that where structure is involved they are not solely of that origin; (2) that as erosional features they are out of adjustment with the present sea level. One explanation of the variation in level is that all the features belong to the same sea level but that there has been deformations, namely a tilt up to the SE. and down to the NW. Against this explanation there are occurrences which do not agree with such a general pattern. Thus, in the NW. there is benching at higher levels, e.g. in the Cape Woolamai-Cape Patterson sector, and in the SE. between Stony Head and Point Sorell on the Tasmanian coast there is offshore a well defined break of slope at 30 f. The alternative explanation is that benching occurred at different levels of the sea in its rises and falls below its present height. Nevertheless, the 30-35 f. level is most widespread and probably represents a more important stillstand.

Features Due to Marine Currents

In the confined passages between the islands of the Furneaux Group and of the Hunter Group are a number of elongated, narrow and deep hollows, which have not yet attracted much comment. This lack of notice may be due partly to their unimportance in the question of land-links and partly to the fact that for the most part they seem to fall unproblematically into the category of tidal scourcolks. Apart from a number of lesser features of a like nature, there are some ten major depressions 20 f. or more in depth. Table 1 sets out the salient facts about them. Reference to the 'Australia Pilot', Vol. II (1944) makes it clear that all these localities are noted for strong tidal currents, which are reinforced strongly by westerly winds. Speeds of 5-6 knots are mentioned with regard to a number of them. On Hunter Passage, there is the typical comment—'5 knots in places at springs, and forming heavy races off the points of the islets, and many swirls and eddies in the channels'. According to the Rev. Brownrigg (1872), the races around the Sister I. were known as 'stonechoppers', a very suggestive name in relation to the ensuing discussion.

The morphology of these features is consonant with these currents being the operative agents in their formation. The deepest holes are usually near the narrowest constrictions in the straits or off projecting points. Thus the Armstrong Channel swale shows two major deeps at the narrowest points along the channel, one (41 f.) between the NE. tip of Clarke I. and Flinders I. and another (46 f.) between Passage I. and Passage Point on Flinders I. Some of them possess in plan a curvature swinging round a projecting headland and corresponding with the current stream-

TABLE 1

Major Current Swales in Bass Strait

Location	General Characteristics	Max. Depth (f.) from Surface	Depth (f.) of Sills	Approx Min. Amplitude (f.) of Enclosed Depression (Lowest Col to Bottom)
Hunter Passage ..	Complex with several deeps. Sinuate plan.	35	5-10 on E., 10-15 on W.	20
Hope Channel (1) against Hunter I.	Two deeps. Very straight in plan.	26	Generally 10-15, but 20-25 on N.	Less than 5
Hope Channel (2) against Three Hummock I. ..	Somewhat irregular in plan.	39	Generally 10-15, but 15-20 on N.	19
S. of Three Hummock I. ..	Curving plan.	20	10-15	5
E. of Three Hummock I. ..	Straight plan.	20	Generally 5-10, but 10-15 on N.	5
Between Swan I. and Tasmania ..	Gently curving plan.	24	5-10	14
Banks Strait near Clarke I. ..	Complex with several deeps. Sinuate and branching.	43	15-20 on W., 20-25 on E.	18
Armstrong Channel and E. to Passage I.	Complex with several deeps. Sinuate plan.	46	5-10 on W., 10-15 on E.	41
Franklin Sound between Flinders I. and Anderson I.	One major sinuate swale. Several minor adjacent ones.	30	Less than 5	20
Between W. Sister I. and Flinders I.	Two deeps. Irregular in plan.	85	10-15	70

lines which occur in such contexts. Some are rectilinear in plan as if a structural lineament is guiding current action. It is unfortunate that on both published and unpublished R.N. and R.A.N. charts, the notations of 'nature of bottom' tend to become infrequent in the neighbourhood of these depressions. However, in one instance they are fully adequate. This is the case of the complex swale in Banks Strait S. of Clarke I. On the floor and round the slopes of the two major deeps in this depression, rock is noted almost exclusively whereas away from the depression westwards and eastwards soft sediments become predominant, chiefly sand and shells. Also the 'Australia Pilot' describes the bottom of Armstrong Channel as 'rocky in deeper parts'.

The only comment on these swales which the writer has encountered is by Edwards (1941), who regarded those in the Hunter Group as relict portions of Pleistocene low sea level river channels. Without rejecting some contribution by such fluvial action to this physiography, it seems unlikely to be the major factor. The ones around Three Hummock I. and the N. end of Hunter I. (a lesser one lies W. of the latter island) are unrelated to any substantial drainage area assuming

a low sea level and the Hunter Passage swale is directed away from the drainage of the main island of Tasmania, not towards it, as is to be expected on Edwards's theory.

Though as a whole the depressions agree with the prevailing conception of a current-scoured swale, the size of the deepest of them, the one N. of Flinders I., seems to call for closer questioning of the morphogenetic processes responsible (Fig. 6). This feature is about 8 m. in length and has a maximum width of $1\frac{1}{2}$ m. It has two steep-sided deeps, the W. being deeper (85 f.) and having a rather flat floor, while the E. is just over 60 f. deep and is much narrower. Between the two lies a col at 40-45 f. situated where the strait is at its narrowest width of 1 m. Granite hills rise fairly steeply on either side, to 636 ft. on W. Sister I. and to 514 ft. on Flinders I. The two deeps have minimum depths below their lowest sills of 70-75 f. and 45-50 f. respectively. The W. sill is very narrow since the swale approaches very closely to the rectilinear structural lineament which cuts Flinders I. off on the NW. There are suggestions of structural control in the irregularly angular shape of the swale. There may be an ENE.-WSW. lineament running along the S. side of the W. deep, through the col and along the N. side of the E. deep. Less certainly indicated are short cross lineaments along WNW.-ESE. lines.

However, it is difficult to regard the feature as of direct tectonic origin, with the two deeps as box-faulted downthrown blocks. Firstly they would be tectonic structures of unusual size and shape. Secondly this depression seems to be simply the deepest in a series of varying size and depth from small, shallow swales, and in the series are many which have no apparent relation to tectonic structure.

The current origin is preferred and it is true that similar features of comparable or even greater depth are known and thought to have such a genesis. Umbgrove (1949) attributes to the monsoon current elongated depressions in the Sunda Straits, which reach to a maximum depth of 66 f. Shepard (1948) gives several instances—a 64 f. hole in San Francisco Bay with a sill of 10 f.; a 95 f. depression in Bahia Nueva, S. Argentina, behind a 28 f. sill; twin holes in Bungo Strait, Japan, reaching down to 228 f. from a rim nowhere deeper than 50 f.; various swales in Tsugaru Strait, Japan, deeper than 250 f., one enclosed by the 50 f. sill. One difference between these instances and the Flinders I. example should be noted. In the other cases there is no nearby alternative passage for the ocean currents or bodies of tidal water to follow whereas in the Australian example there is ample room for the water masses to pass N. of the Sister I., indubitable though the tidal race is over the swale.

The theory that such a deep cavity as this at the N. end of Flinders I. is due to current action is a rather demanding one and seems to call for somewhat more elaboration than is found in the textbooks of submarine geology. Firstly as to process, actual excavation to such depths seems much less likely than the inhibition of deposition over the site of the holes with the gradual accumulation of sediment around where the currents were less strong. The Snellius Expedition (Kuenen 1935) found that strong currents prevented deposition in the Indonesion straits where rock bottom was found in many places. Secondly there is the question of time. Whether the process be one of positive erosion or of hindrance to deposition, it is difficult to regard this particular depression, at least, as the product of current action since the Postglacial Flandrian Transgression or even as the product of all the interglacial high sea level periods of the Pleistocene. It is more convincing to envisage its formation as the consequence of inhibition of deposition from some much earlier time in the Cainozoic. At this point the disposition of the Palaeozoic granite masses was such as to promote the development of tidal races whenever sea

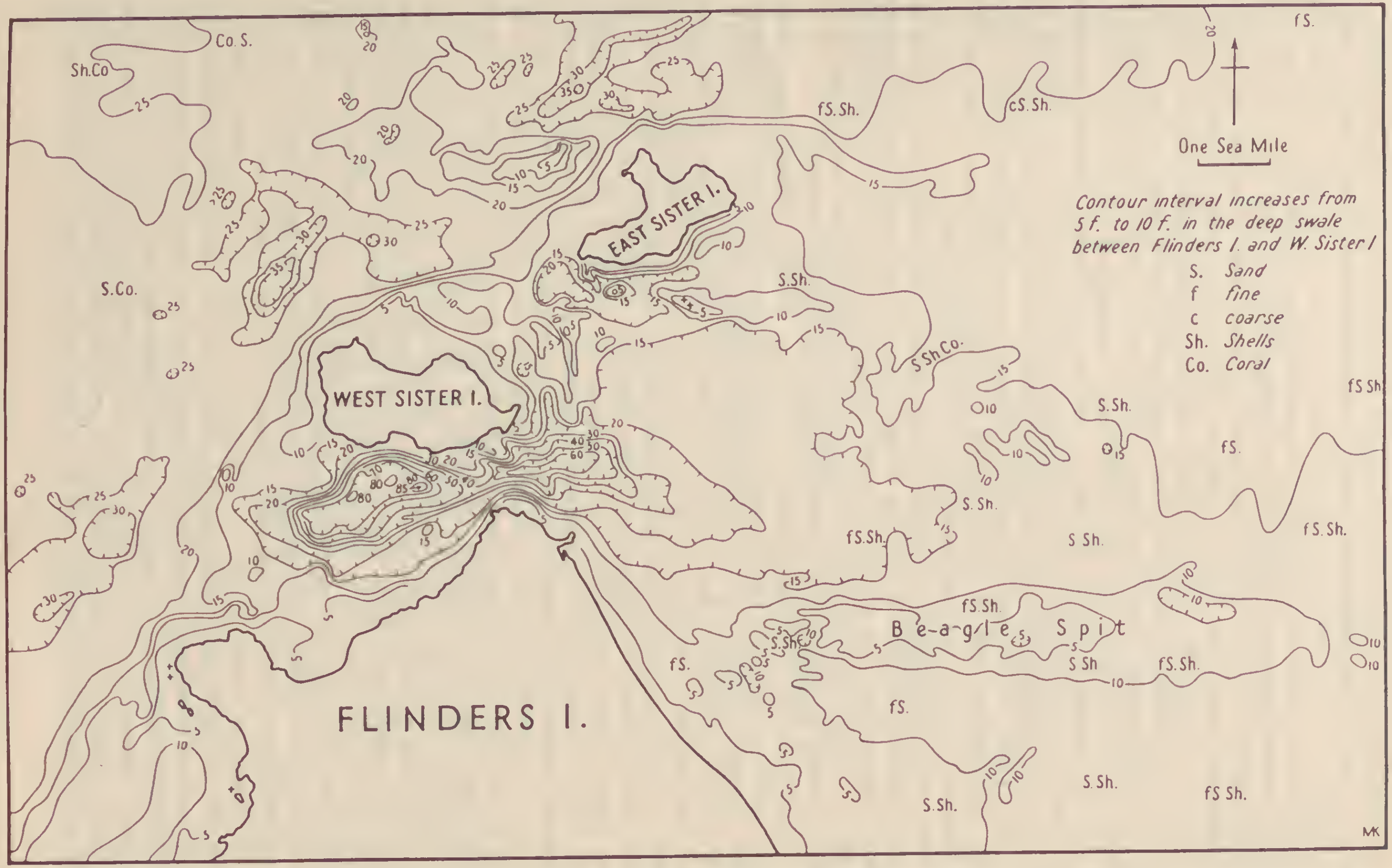


Fig. 6.—The deep enclosed depression N. of Flinders I.

level was at all close to its present one relative to the land, and sediments from perhaps as early as the Miocene may have failed to accumulate in these confines. Whenever the area emerged, there would be some infill (both from mass movement on the surrounding slopes and from streams) of the lake which would appear. But the general configuration would not have been very favourable to any large integration of drainage into it. In each subsequent transgression there might be some evacuation of unconsolidated sediment by tidal currents, a much less exigent task than the erosion of the whole depression from consolidated rock. A long, repetitive history of this type may be envisaged. The absence of a breach in the straight structural scarp which lies so close to the depression, rather suggests that the postulated faulting along this line is later in date than much at least of the life of the enclosed swale.

Three substantial features in the Furneaux Group seem to be constructional submarine forms associated with the marine currents of the lesser straits. Because of the predominantly W. wind regime and the Southern Ocean current setting eastwards, the currents flowing eastwards are both faster and last longer than those flowing westwards. Beach and longshore drifting directly due to waves will also be preponderantly from W. to E. In consequence there will be a substantial net transport of sediment eastwards. The three features to be discussed all significantly lie on the E. side of the Furneaux Group.

At the E. end of Franklin Sound there is a large 'tidal delta' some 7 m. by 5 m. across. Through the semi-circular line of sandy shoals, which include Vansittart Shoals and the Potboil, there is no passage as deep as 5 f. This encircling ring of sediment is deposited where the currents, previously confined to the Sound, spread out losing speed and encounter the Pacific swell.

Beagle Spit, an elongated sandy shoal some 10 m. long and up to 2 m. across, runs eastwards from a point a little S. of the E. extremity of the Flinders I.-Sister I. swale. In plan and form it appears to be unrelated to bedrock structures in the vicinty and is regarded as constructed of sediment brought through the strait on the W. and dissipated to the flank of the dissipating current. The current between the two Sister I. prevents an exact counterpart on the N., though there are two smaller similar features trailing eastwards from the N. and S. sides of E. Sister I.

Equivalent in size and shape to the Beagle Spit, is the shoal trending eastwards from the S. tip of Clarke I. It bears a rather similar relationship to the Banks Strait current as Beagle Spit does the race to the N. of Flinders I. It is made up of the sandy shoals of Moriarty Bank, East Bank and their continuation but the Moriarity Rocks project through its surface. Nevertheless, it is interpreted as a constructional feature closely comparable to Beagle Spit. A pertinent objection to this interpretation of these eastward trailing spits is that they are different in form from the Frankland Sound lunate bar attributed to fundamentally the same cause. However, there are differences in the circumstances. In the Franklin Sound case much more shoreline feeds into a narrow exit. Proportionately more material will be dumped at the E. mouth shallowing wide areas and making the whole delta subject to pronounced wave attack. In the other two cases supplies from coastal erosion must be smaller and conflicting currents from other straits can interfere. There is only material for accumulation in the most favoured locus. At the same time the questions remain as to why the E. tips of these submarine spits are streamlined and not blunted by wave action from the E. and why no constructional features at all occur in relation to Armstrong Channel's E. exits. More data and more rigorous analysis than can be given here are necessary before such questions can be resolved even partially.

Other Features

NE. of Flinders I. lie two areas of low ridges, the full extent of which is not known because they are cut off abruptly by the limits of close modern sounding (Fig. 7). The amplitude from crest to trough of the E. ridge area is 3-5 f., the W. ridges rise more boldly, up to 7-8 f., and their crestlines seem more undulating. The sea floor in general is declining gently from SSE. to NNW., the E. area rising from the 20-25 f. level, the W. area from depths a little greater than 25 f. The E. group of ridges run in crudely parallel fashion WSW.-ENE. along the general slope, with a few outer discrepant ones trending NW.-SE. This latter trend is dominant in the W. group, which, however, reveal more general branching and inflexion. All bottom notations refer uniformly to sand and shells, with an occasional mention of coral, but they are placed entirely in the troughs and flats intervening between the ridges. Nevertheless, it is extremely likely that the latter also consist of recent sediments since if they had been bedrock ridges this would have been too significant for navigation to have passed unrecorded in the bottom notations .

The interpretation of these features is extremely difficult and objections can be raised against the conceivable mechanisms.

1. Tidal Current Origin. Against this is the fact that although the E. group is in the main sympathetically arranged with the reversing tidal currents, which pass through the straits between the Kent Group and Flinders I., the W. group is disposed transverse to them. Moreover, the latter ridges are too complex and sinuous in plan for tidal banks. These W. ridges seem to be made up of short hummocks unlike tidal banks. Their rounded stubby ends bear little resemblance to the tapering, streamlined points of the latter. Also, in both groups the intervening flats are far wider than the ridges themselves. Where tidal scour is involved it is more usual for the channels to be narrower than the tidal banks themselves. Tidal current origins seem untenable for the W. group at least.

2. Ocean Current Origin. Much the same case can be made against the slower, yet more widespread and more persistent Southern Ocean Current as against tidal currents.

3. Wave Construction Origin. Wave-built submarine bars would be much more nearly parallel in trend than these ridges. Moreover, the difference of predominant trend from the E. to the W. group is even harder to reconcile with such origins since the wave regime can hardly differ so drastically from the one area to the other. More even crestlines than the W. group possess seems required by this hypothesis.

4. Coastal Dune Origin. If the ridges are considered as relics of a Pleistocene low sea level period exposing this part of the shelf, the subaerial features, which they most recall, are coastal dune systems. However, although on the lee side of the Bassian Rise, they are now out in the open ocean and it is difficult to see how such features could have withstood the attack of waves and currents as sea level was rising from its last low still stand to its present level. This difficulty seems insuperable with quartz sand dunes, less so with calcareous dunes consolidated to aeolianite, for Sprigg (1952) maps a submerged aeolianite dune ridge in front of Guichen Bay, S. Australia (admittedly close inshore). However, the probability is that any dunes formed in this area would be quartzose. Calcareous dunes range from W. Australia through S. Australia and W. Victoria to NW. Tasmania. From SE. Queensland through N.S.W. and E. Victoria to E. Tasmania the coastal dunes are of quartz

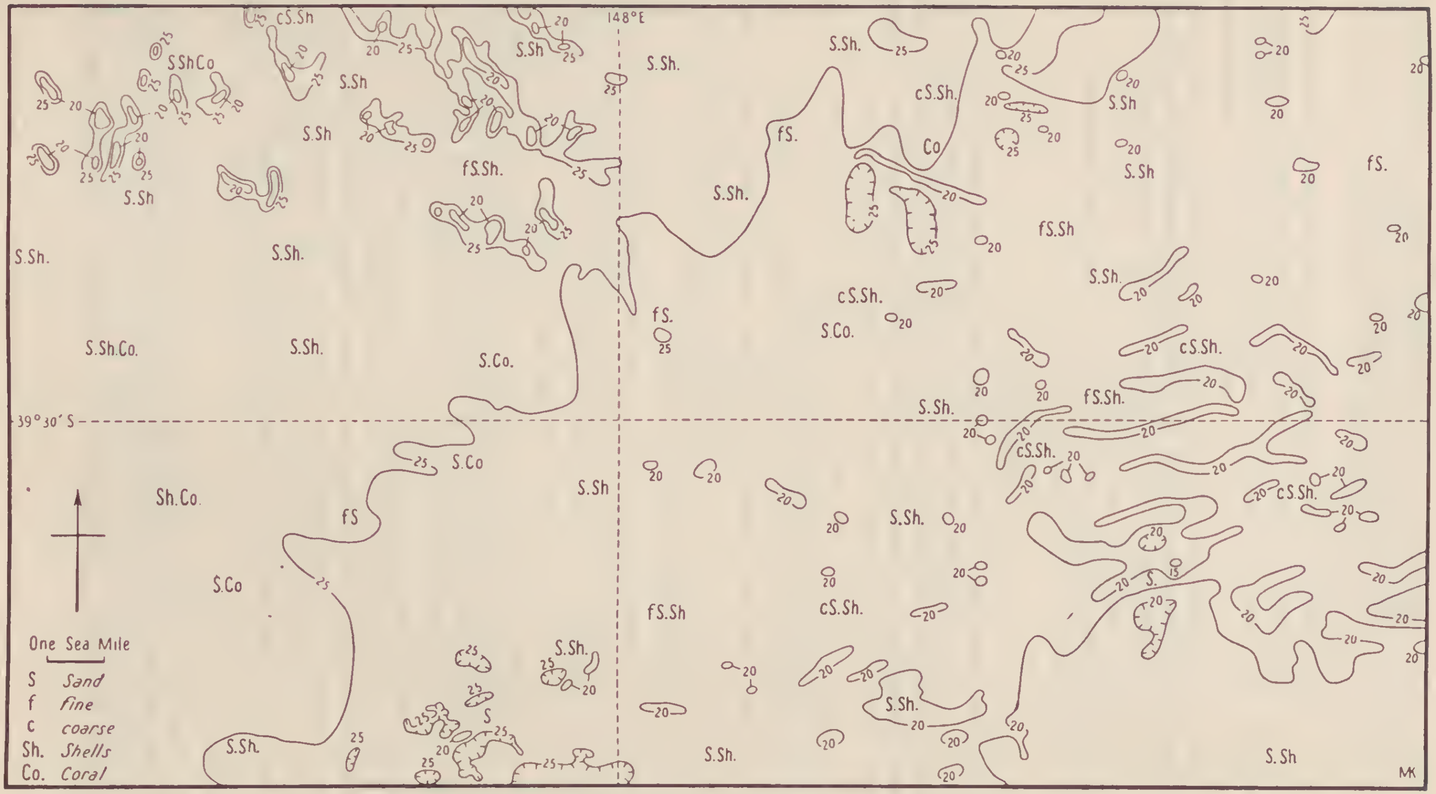


FIG. 7.—Submarine ridge systems of obscure origin NE. of Flinders I.

sand. The Bass Strait islands constitute the meeting ground of the two systems. Aeolianites ('Helicidae' Sandstones of Johnston 1877) occur both in the Furneaux Group and King I. But in King I. (Jennings 1957) aeolianites are found on the W. coast and quartz dunes on the E. coast.

Moreover, the differences in trend remain to be explained since the low sea level shorelines would have run ENE.-WSW. through the whole area. The implication would be that the E. group consists of a simple series of coastal foredunes comparable to those of the S.E. Province, S. Australia (Sprigg 1952), whereas the W. group is mainly perpendicular to the low sea level shorelines and would constitute parabolic dunes. The differences in relief to be detected between the two groups may correspond in some degree with such a difference in dune character and the plan of a few of the W. ridges seems to be parabolic.

But on present evidence the question of origin remains open and hardly capable of resolution without submarine boring.

Summary

It will have been recognized that the preceding discussion consists to a considerable degree of a critique of previous views on the submarine features of Bass Strait. On the rather more assured basis of the fuller bathymetrical data, it is possible to confirm many characteristics already recognized, but it has also proved necessary to qualify some details and to question seriously certain wider assertions.

1. It is considered that in this region even modern sounding does not justify extremely close contouring of areas of subdued relief.

2. The major features—Bassian Rise, King I. Rise, Tail Bank, Otway Depression, Bassian Depression, and Flinders Depression—were all recognized by previous workers, but the descriptive terms (rise, depression) are introduced in place of those employed earlier (ridge, trough) as being more in keeping with the generally subdued character of the submarine relief concerned.

3. These major features appear to be tectonic in nature. Palaeozoic trends have been both revived and disrupted by later faulting, probably Tertiary in age. Certain linear submarine scarps survive which may be in part at least true fault scarps.

4. The new data support Dannevig's objection to Noetling's extension of the Tail Bank to the Victorian coast to enclose a Bassian Depression of substantial depth. The shallow enclosed basin which does exist is probably due to tectonic subsidence, though there is little in the topography of the bounding features to support the claim of some authors that the movements are extremely recent geologically.

5. It is maintained, contrary to Keble, that the Otway Depression is in the main very featureless and gives no evidence of a former course of the Yarra fashioned during a Pleistocene low sea level. Nor can a Tamar Major course be detected across the Bassian Depression, though detailed soundings are still lacking for an important central region. This remarkable smoothness of much of the Bass Strait floor is not regarded as an argument against Pleistocene exposure to subaerial attack but as testimony to wave action in a stormy shelf sea during higher sea levels than those which did in fact expose it.

6. The manner in which many stretches of coast and a number of islands, reefs and shoals rise abruptly from a nearly flat sea floor level much below the present sea level is regarded as the product of marine action at Pleistocene low sea levels. The importance of breaks of slope at 30-35 f. suggests a pronounced stillstand at that level.

7. Numerous elongated swales in the passages amongst the Furneaux and Hunter Groups are interpreted as due to tidal and other marine current action. The deepest one N. of Flinders I. is discussed more fully and this one at least is thought to be the result of the inhibition of sedimentation by marine currents in a narrow gap between granitic masses over a long period of geological time.

8. Three large features—two submarine spits and a lunate bar—are attributed to the deposition of sediment carried through the Furneaux straits from the W. by marine currents.

9. Attention is drawn to two groups of submarine ridges lying NE. of Flinders I., though on present evidence little of a positive nature can be said of their morphogeny.

The understanding of the modern biological distributions of the Tasmanian islands can only be established satisfactorily by the study of their Pleistocene deposits and those of Victoria. Nevertheless, the bottom topography of Bass Strait is pertinent to the comprehension of the migrations involved and it is hoped that this paper puts the knowledge of that topography on a firmer basis. In that topography itself there are certain points of more than regional interest, perhaps of systematic significance. The featurelessness and uniformity of much of its floor, interpreted as the result of Pleistocene low sea level erosion and sedimentation, may not be matched from many other seas of the world. Also the Strait adds one further deep enclosed depression to the comparatively few so far known from the continental shelves. This example prompts an elaboration of the genetic notions so far offered for these features.

But the topography on its own raises more questions of morphogenesis than it can answer. Geological exploration of the sea floor in Bass Strait is awaited.

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